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A REVISION OF THE ATOMIC WEIGHT OF ZIRCONIUM.[1]

BY F. P. VENABLE.

PREVIOUS DETERMINATIONS OF THE ATOMIC WEIGHT.

It is perhaps best to give here a brief outline of previous determinations of the atomic weight of zirconium. Six such series have come under my notice. In three of these the sulphate was used, and in the others the chloride and the double fluoride of zirconium and potassium were used, and in one the selenate.

The determinations of Hermann,[2] by means of the chloride, can be dismissed as untrustworthy, because of his failure to overcome the difficulties inherent in the use of the chloride as shown by Bailey's work and my own.

The work of Marignac upon the double fluoride I am not in a position to criticise properly, except in so far as to say that his analyses are not very numerous, and that they show a range of nearly three units in the atomic weight.

In 1825 Berzelius ignited the sulphate and gave six determinations of the ratio of the sulphate to the oxide. In

[1] Read at the Washington Meeting American Chem. Society.

[2] *J. Prakt. Chem.*, *31*, 77

some of the experiments he also precipitated the zirconium hydroxide by means of ammonium hydroxide and determined the sulphuric acid in the filtrate by precipitation with barium chloride.

Mats Weibull also used the sulphate and reports seven experiments with an entire consumption of 8.2335 grams. Bailey's own determinations number eight, using in all more than sixteen grams. He gives full data as to his work, and it is well done and merits very careful attention. The following table is copied from his article.[3] The figures have been recalculated to the basis of O=16.

	Mean	Maximum	Minimum	
Zr : Cl	88.77	....	....	Hermann
ZrO_2 : HCl	90.14	90.98	89.29	Hermann
K_2ZrF_6 : K_2SO_4	90.53	92.80	90.06	Marignac
ZrO_2 : K_2SO_4	90.64	91.26	90.24	Marignac
K_2ZrF_6 : ZrO_2	90.8	91.3	89.9	Marignac
$Zr(SO_4)_2$: ZrO	89.45	92.65	89.27	Berzelius
$Zr(SO_4)_2$: ZrO_2	89.48	90.38	89.13	Mats Weibull
$Zr(SO_4)_2$: ZrO_2	90.65	90.78	90.46	Bailey

It is manifest that the determinations based upon the ignition of the sulphate are the only ones worthy of further attention. A brief criticism of these is necessary. First, as to Mats Weibull, Bailey says that the temperature used by him in freeing the sulphate from the excess of sulphuric acid was some 50° too low. This would of course give him variable and low results. Berzelius does not give exact data as to temperature used, but he seems to have heated the sulphate too high in driving off the excess of acid. Possibly more stress is to be laid upon the question of the purity of his sulphate and the correctness of the assumption that he had in hand the normal sulphate.

Bailey concludes from his experiments that the sulphate is stable up to 400° C., and that the excess of sulphuric acid can be completely driven off by the use of a temper-

[3] *Chem. News*, 60, 17.

ature between this and 350° C. He further states that a mixture of the salt and free acid, as prepared by him, when heated to this temperature until constant, yields the normal sulphate. It must be said that he gives no proofs of this beyond the amount of zirconia found in his atomic weight determinations.

Whilst certain criticisms of the work of Bailey have occurred to me, I will refrain from mentioning them until I have had opportunity to repeat his experiments and so make myself more familiar with the details of his method.

One criticism I can venture upon now, however. I doubt whether it is possible to ignite, without loss, zirconia along with ammonium carbonate, as was done by Berzelius and by Bailey to remove the "last two or three milligrams of sulphuric acid." I have not ventured to use this method in getting rid of the chlorine which is held just as tenaciously as the sulphuric acid, as I feel sure that it could not be done without loss. Bailey adopted extraordinary precautions to prevent this loss, but it seems to me that it is not the currents of the external atmosphere, as he maintains, which are to be most avoided, but the mass of escaping vapor of the ammonium salts. It is easily possible for him to have lost several milligrams of the finely-divided zirconia in this way, and as he states, each milligram was equivalent to a variation of 0.25 in the atomic weight.

THE WEIGHINGS.

In the following experiments the amounts of substance used varied from one to five grams. To avoid the disadvantage of a small error causing a large variation in the result, I would gladly have used larger amounts of the chloride, but many difficulties met me there. The purification of the zirconium oxychloride is slow and costly. It is best carried out in small portions of a few grams at a time. Some fifty grams have constituted the stock at my

command. The drying of large portions and the subsequent ignition would be exceedingly tedious and time consuming, besides requiring such apparatus as could not be well afforded. Five or six grams have been about the largest amounts that could be well handled at one time. Even such an amount as that required from sixteen to twenty days for the completion of the experiment. It could not safely be hurried through in shorter time.

The weighings were carried but upon an excellently constructed Sartorius balance, intended for a load of 200 grams. The heaviest apparatus used weighed less than sixty grams. The weights were corrected by one which had been compared with the standard at Washington. All objects were weighed against a tare of as nearly the same size, form, and weight as possible, all of the flasks, crucibles, etc., being made in pairs. This partly avoided the necessity for a reduction of the weighings to a vacuum and corrections for moisture, pressure, etc. Such corrections would have had little meaning in comparison with the other inaccuracies of the process and manipulation, and could only serve to give a false appearance of excessive accuracy. The objects were left one-half hour in the balance-case before weighing, experiments having shown that this time was sufficient. Of course the adjustment of the balance was carefully watched, and the balance, which has been used very little, was put to no other use during the progress of these experiments.

METHOD OF WORK.

The purified oxychloride was introduced into a small glass flask having a capacity of 100 cc. This was provided with a glass stopper ground to fit, and also a second one with two tubes arranged for the passage of the hydrochloric acid gas. The arrangement of the tubes was similar to that in an ordinary ether wash-bottle, though both tubes outside were bent downwards and had little

bulbs blown in them for catching moisture, etc. A Thörner bath was found to be very convenient for keeping these flasks at 100° C. The hydrochloric acid was prepared by allowing sulphuric acid to drop into a large flask containing the hydrochloric acid. The gas thus obtained in a regular stream, was passed through a wash-bottle containing sulphuric acid and then through towers filled with glass beads kept moist with concentrated sulphuric acid.

The drying took from fifty to one hundred hours (in some extreme cases.) If the stream of gas was rapid the temperature could rise to 110° or even higher without decomposition of the chloride. A much lower temperature caused this decomposition if the stream was insufficient to keep the flask full of gas. A number of experiments were carried out showing these facts. Indeed, two in the series of determinations were lost by the stream of gas becoming too slow or altogether ceasing for a short while. (Experiments VI and VIII.) It was thought from experiments at first that where this decomposition had begun it was impossible to secure a constant weight of the residue, but this is certainly not true where the decomposition has been only slight. Of course this introduces a chance for error in the method. The drying must be watched quite closely, and not more than eight or ten hours of drying could be easily managed in a day.

At first it was feared to remove the atmosphere preparatory to weighing, and efforts were made at weighing the flasks full of hydrogen chloride. These results were too low and varied among themselves, so that it was evidently impracticable to carry out the experiments in this way. It was found that the hydrochloric acid could be replaced by dry air. The flask was removed from the bath and dry, pure air passed through it for half an hour. It is of course essential that the air be carefully dried. The tubes were then removed and the glass stopper quickly

fitted in its place. It was then ready for placing in the balance-case. The chloride is deliquescent and some trouble in weighing was experienced. If the stopper was well ground there was no appreciable change in the weight in from twenty to forty minutes after placing upon the balance. The loss of weight in the latter part of the drying was very slow. The weighings were taken at intervals of from six to eight hours' heating. The number of weighings necessary before constancy was secured served as a safeguard against error. A series of such weighings is given further on.

After drying, the chloride was dissolved in a small amount of water (redistilled) and this solution, with rinsings, transferred to a platinum crucible. It was evaporated to dryness upon a water-bath, with due precautions against dust, etc., was next heated gradually upon a sand-bath until most of the chlorine had been driven off, and was then slowly raised to the highest temperature attainable by the Bunsen burner. During this latter part of the operation the cover was kept on. Three or four days were thus consumed, the gradual heating giving a coherent flinty mass of glistening semi-translucency which could be safely heated by the water-blast without loss. During the driving off of the chlorine the platinum crucible was more or less attacked, but as this was before the lid was on, there was little chance of loss from this source. This corroded platinum was probably the reddish-brown decomposition product mentioned by Bailey as coming from the ignition of the oxychloride.

The last of the chlorine was driven off by heating with a water-blast for from forty-five to seventy hours. The last weighings were made at intervals of from six to twenty hours and were recorded as constant if they agreed within 0.00005 of a gram. A series of weighings is here given as an example. Experiment No. II, or the first

one successfully carried out in the series, is taken for the purpose.

Weights of zirconium oxychloride:	March	28	5.25910
" " " "	"	29	5.25786
" " " "	"	30	5.25760
" " " "	April	1	5.25762
Weights of zirconium oxide:	April	11	2.78759
" " " "	"	12	2.78724
" " " "	"	13	2.78583
" " " "	"	15	2.78517
" " " "	"	16	2.78452
" " " "	"	17	2.78451

This zirconia was examined for chlorine in most of the analyses and was found to be free from it. In the last three experiments reported in the series, the ignited residue was treated with hydrofluoric acid. Ignition after this treatment was very difficult, as the mass was not compact and coherent. The finely divided zirconia was lost in spite of the most careful treatment. The first was lost altogether and the weighing was not carried out. The second showed, upon the lid signs of the powdered zirconia having been swept out. The total loss of weight, however, was less than one milligram. This could readily be attributed to the zirconia and pointed to the absence of silica unless in insignificant traces.

I think great purity may be claimed for the preparations used in the analyses. Crystallizing from hot hydrochloric acid is apt to remove most known impurities, and they were eliminated beyond the possibility of detection by the ordinary tests. The analyses were not made from the same preparation, but from small quantities prepared at different times and some crystallized ten or a dozen times more than others, yet no appreciable difference could be detected in the results. That these results are not in close accord with one another, is due in part to the deliquescence of the chloride and to the risks involved in the prolonged heating of the oxide.

SOURCES OF ERROR.

Five main sources of error have occurred to me apart from any question as to the purity of the material.

1. The deliquescence of the chloride.

2. The loss of the finely divided zirconia.

3. The corrosion of the platinum crucibles.

4. The attack of the glass flasks by the gaseous and aqueous hydrochloric acid. It is very evident that the glass vessels would suffer when subjected to the action of hydrochloric acid during such prolonged periods. The weighings easily revealed the extent of this action. It was found to vary with different flasks. For instance, flask I lost 0.00116, 0.00031, 0.00023, and 0.00078 gram. On the other hand, flask IV weighed after the first experiment only 0.00011 gram less, and after the next two experiments the loss was 0.00013, and the total loss during three experiments was 0.00024. This is probably transferred mainly as alkaline chlorides to the crucibles and is there volatilized. Sodium could readily be detected upon the lid of the crucible after partial ignition. Of course if all is volatilized then no error is introdued into the experiment, but there may be some non-volatile material also transferred from the flasks. The total amount is so small that the error cannot be a large one.

5. Substances carried into the drying flasks by the stream of gas. Much care was taken to avoid error from this source. The main danger lay in the necessity for the use of some rubber connections. Vulcanized rubber was used. It was freed from excess of sulphur and was replaced by a fresh piece when sttacked by the gas. The dry gas does not attack rubber very rapidly. Gaseous sulphur compounds, coming from the sulphuric acid, used in preparing and drying the hydrogen chloride, were probably carried through the drying flasks, but there seems to be no probability of their causing a decomposition of the oxychloride.

THE DETERMINATIONS.

All analyses which were completed under the proper conditions of the method, as already given, are here reported. Experiment III became contaminated from the iron support during the prolonged heating and came out consequently a little high, giving the ratio of ZrO_2 : $ZrOCl_2.3H_2O$ as 53.12. In most of the subsequent analyses the ignition was carried out with the crucible suspended in a platinum wire cage from a glass support. Experiments VI and VIII were dried with an insufficient stream of gas, as already stated, and hence were partially decomposed. They gave 53.57 and 53.8, respectively. The remaining analyses follow:

	$ZrOCl_2.3H_2O$.	ZrO_2.	Ratio.
II	5.25762	2.78459	52.961
IV	3.53994	1.87550	52.981
V	3.25036	1.72435	53.051
VII	1.52245	0.80708	53.012
IX	2.98802	1.58274	52.969
X	2.11371	1.11820	52.949
XI	2.38139	1.26161	52.978
XII	1.90285	1.00958	53.055
XIII	8.61847	1.38658	52.024
XIV	1.07347	0.56840	52.951
	26.64828	14.11953	52.986

Calculating these for the ratio $ZrOCl_2.3H_2O$: ZrO_2, taking H=1.008, O=16, and Cl=35.45, we have the following:

Maximum ratio	53.055	Atomic weight	91.12
Mean "	52.986	" "	90.78
Minimum "	52.951	" "	90.61

The atomic weight as determined by Bailey is 90.65. The mean valne given in Clarke's Recalculation is 90.40. I purpose repeating the determinations with the oxychloride, with such modifications as have occurred to me since the completion of the above work.

NOTES ON DARBYA AND BUCKLEYA.

W. W. ASHE.

The limited and localized distribution of *Darbya* and *Buckleya*, two genera of southern Appalachian plants (*Darbya* a monotypic genus and *Buckleya* with one Japanese species and the east American plant which is under consideration) has frequently since their discovery been a subject of comment among American botanists. Among the chief factors which have limited their distribution, as Professor Sargent[1] has pointed out in the case of *Buckleya*, are the fact that the sexes are confined to different plants, and the rapid degeneration of the oily albumen surrounding the embryo: the first being an obstacle to the formation of seed; and the latter injuring or destroying the germinating powers of the seed unless they early reach a suitable place for sprouting. Both thus check the increase of new plants.

Another fact which has apparently been overlooked in connection with these plants and which is probably also in a large measure accountable for their localized distribution, is that no efficient means is provided for seed-dissemination. All animals that I have tried with the seed reject them; in regard to birds I cannot speak. The heavy fleshy seed have evidently been developed to sprout and grow near the parent plants. The seed of *Buckleya*, it is true, since it is found only along and near streams, are apt to be transported by the stream. This is evidently the case with *Buckleya* along the French Broad and Pigeon rivers. Kearney[2] records it as growing at an elevation of 30m above the river on the side of a wooded

[1] Gard. and Forest 3: 236.

[2] Bull. Tor. Bot. Cl. 24: 561.

bluff near the original station at Paint Rock. I have noticed it, however, only a few meters at most away from the river or from some stream.

But what I regard as restricting the distribution of the plants fully as much as any of the above assigned causes is the heretofore unrecorded fact of their parasitism. Although Dr. Gray[3] dug up *Buckleya* to remove it to Cambridge for the botanical garden at that place; and more recently Professor Sargent[4] has carried both seed and young plants from Paint Rock to the Arnold Arboretum, where a few of the plants were induced to grow, it was not noticed by either that *Buckleya* formed root-attachments to other plants. Great difficulty was encountered in inducing the plants to grow, and what is not strange, all means of propagation failed. Mr. J. G. Jack writes me that one of the plants of *Buckleya* which Dr. Gray took to Cambridge lived for a great many years beneath a hemlock where it was planted in the Botanic Garden and to the roots of which I think it had undoubtedly formed attachments.

I have been aware of the parasitic nature of these plants for several years. The parasitism of *Darbya* was first discovered, and subsequently that of *Buckleya*. In the autumn of 1894 Mr. F. E. Boynton and I collected specimens of *Darbya* near Salisbury, N. C., where I had previously noticed the plants. He had already suggested the parasitism of Pyrularia, as recently published,[5] and which I was soon after able to verify. We consequently suspected the parasitism of *Darbya*, knowing that many of the *Santalaceae* are root-parasites.[6]

[3] Gard. and Forest, l. c.

[4] Ibid.

[5] Distribution from Biltmore Herbarium: *Pyrularia oleifera* Mx, parasitic on roots of trees etc.

[6] Hieronymus (Die Natuerlichen Pflanzenfamilien von Engler und Prantl, 203) gives only the following genera as being root-parasites: Osyris, Santalum, Commandra, Thesium, Arjona, and Quinchamalium.

On carefully digging up the plants the roots, or what I rather regard as prolonged subterranean stems, were found to be very much as Miss K. A. Taylor[7] has described them. The plants propagate by these underground stems which are 8-15mm in thickness and similar to those of *Commandra*, but larger. These, in the centre, are firm, tough and woody. This core of wood is covered with a thick, tough, though rather corky bark, 3-4mm in thickness. From the lower side of this are frequent small roots, none of them over 3mm in thickness which form attachments to the roots of the trees and shrubs growing around. These slender roots are attached to the host by disk-shaped haustoria, somewhat similar in structure to those described for *Commandra*.[8]

Miss Taylor[9] gives the length of the "roots" dug up at Columbia, S. C., as being only a few yards. They are frequently very many yards in length, however. One plant I recently had dug up, had an unbroken stem measuring nearly 10cm, and as there was a growing-point at only one end the length must have exceeded this. The vegetative stems are apparently developed in no regular order and from no evident buds, though this will bear farther examination. The stems lie from 12-15cm below the surface and fork at frequent but irregular intervals. The underground stems are tipped with a growing-point in appearance not unlike that of many of the large roots of plants. As this growing-point pushes forward during the season of growth, many small roots are developed from the lower side of the newly formed stem. These penetrate either straight down or somewhat laterally until they reach the roots of some tree or shrub suitable for attachment, where haustoria are formed. The longest of these roots found was about 3cm in length. While

[7] Gard. and Forest, 7: 94.

[8] Von Schrenk, Bul. Tor. Bot. Cl. 12.

[9] Gard. and Forest, l. c.

developing and before attachment is secured they are covered with thin-walled cells, but old roots which have been attached to a host-root for some time, appear to have enlarged while the walls of the epidermal cells have become thickened. It is possible that the newly developing root is capable of absorbing from the soil, while the older ones that have already made attachment are no longer able to absorb; but neither of these statements is yet definitely known to be true. And since the seedling plant of *Buckleya* as I have recently found out by planting them, is thus able to exist for some time without the intervention of attachments, it is quite possible that not only the young plants of *Darbya* may do the same, but that newly developing roots as well may possess this ability to derive nutriment from the soil. This, however, is merely conjecture. These roots showed few forks and no roots could be found, except those developed in the spring, which had not formed an attachment or were evidently broken, so it is probable that those roots which do not find attachment soon lose their vitality and die.

Polygamous plants seem to mature fruit only when fertilized by staminate plants or perhaps by other seedling polygamous plants. Near Chapel Hill in the lower valley of Morgan's creek polygamous plants are found for three or four miles along the narrow strips of alluvial soil that border the creek, but no seed are produced. This would seem to indicate that all the groups of plants along Morgan's creek have a common origin and are vegetatively produced from a common stock. The staminate plant is not found near Chapel Hill.

Near Salisbury, N. C., many groups of the sterile plants are to be found within an area of two or three square miles, but as no trace of a polygamous plant has been found within twenty miles of these groups I am inclined to trace these, as well, to a common plant and derived from it vegetatively. This view is further strengthened

by the fact that in the few localities where seed are produced both sexes occur abundantly, though usually the plants are separated into more or less evident groups, as Miss Taylor[10] observed at Columbia, S. C.

If these disassociated groups of plants are of common origin, *Darbya* would seem to be, under its natural conditions, a plant which readily and rapidly propagates. In one place the underground stem seemed to have made as much as three feet of growth in one year.

I have extended the distribution of *Darbya* as far north as Halifax county, southern Virginia. Dr. Mohr has found it as far west as northern Alabama; and in Georgia it has been found as far south as Macon. The most eastern place where it has been found is near Willardville, Durham county, N. C. I have recorded from my own observation thirteen stations for the plant in Virginia and the Carolinas, the numerous groups of plants around Salisbury and Chapel Hill, and similar groups at other places, being regarded as constituting a single station. At only three of these stations are seed known to be produced. The staminate plants are much more abundant than the polygamous.

As in the case of *Commandra* attachments are made to the roots of most trees and shrubs. The following have been verified to serve for *Buckleya:* Quercus alba, Q. minor, Q. velutina, Q. Marylandica, Q. nigra; Pinus echinata, P. Virginiana; Hamamelis; Vaccinium corymbosum, V. vaccillans; Hicoria Carolinae-Septentrionalis, H. alba; Crataegus sp. ign.; Acer rubrum. It is probable that this list could be extended by carefully following the roots.

Darbya, I am convinced, can be grown by planting the seed among trees or shrubs that will serve as hosts in a place where it will not be necessary to move it. If it is desired to move the plants the seed should be planted in

[10] Gard. and Forest, 7: 94.

jars with seedling oaks or pines, and when large enough to set out remove the contents of the jar without disturbing the roots of the plants.

Buckleya, since it sometimes reaches the size of a small tree, is the largest known American parasite. It has many more fibrous roots than *Darbya* and the subterranean stem is not so extensive. The clasping disks by which attachments are made are larger and somewhat more cup-shaped than are those of *Darbya*. It is chiefly parasitic on the small roots of hemlock, beech, sugar maple, birch (sp. ind.) and red oak. It can be cultivated in the same manner as *Darbya*.

The manner of propagation of *Pyrularia* is like that of *Darbya* but the underground stems are shorter and more abundantly supplied with small roots.

ROBINIA BOYNTONII SP. NOV.

[1]CONTRIBUTION FROM MY HERBARIUM. NO. II.

W. WILLARD ASHE.

For many years a plant which was originally described by Pursh[2] as *Robinia hispida* var. *rosea* has been confused with the *Robinia hispida* of Linnæus by both American and European authors. This confusion originated from the inadequacy of Pursh's[3] description; and has been continued by later writers who, having no specimens of Pursh's plant for comparison, transferred its name to smooth or nearly smooth forms of *R. hispida* which seemed in part to agree with the description of the variety *rosea*. As a matter of fact the variability of

[1] Recieved March 18th, 1898.

[2] Flora Amer. Sept. 2: 488.

[3] *Robinia rosea B.* R. foliolis plerumque alternis, ramulis glabriusque.

hispida in those characters which were usually relied upon for segregation has justified it.

Pursh, in spite of his brief and unsatisfactory technical description, in making some general references to the distribution, etc. of the plants he had just described, compares the relative sizes of *R. hispida* and *R. hispida* var. *rosea* in such a manner as to leave no doubt in regard to their identity: "The variety *B* is less hispid and grows to a considerable large upright shrub, whereas the original *hispida* is a low straggling plant." This acurately presents the salient features of the habit of the two plants, and enables one, familiar with both in the field, to easily differentiate the true *rosea*.

But while usually a form of *hispida* is referred to *rosea*, in the last edition of Gray's Manual of Botany[4] the description of *hispida* includes not only all the true forms of *hispida*, but the *rosea* of Pursh as well, the latitude of the description embracing plants with "less bristly or naked branches, smaller flowers etc." than the immediately preceding technical description covered. The allusion to small-flowered forms can only be interpreted as a reference to *rosea*, as a comparison of the description of the two plants which follows will show.

It is probable that Marshall as well included both plants in his *rosea*, which is usually referred only to *hispida*, as he mentions the large size that some specimens of his plant attain, whereas the true *hispida* is always of small size.

American botanists, when separating the two plants at all, have retained the *rosea* under its original name, and where first placed as a variety of *hispida* but the two plants are so different that *rosea* is eminently worthy of specific rank.

As no additional names have been proposed by European botanists there is no tortuous synonomy to be traced.

[4] Sixth edition, 134.

Robinia dubia Fouc.[5] and the other names included in its synonomy refer to a plant which has long been cultivated in Europe, and which, if not a hybrid[6] between *R. Pseudacacia* and *R. viscosa*, is a garden variety of *R. viscosa*. It is separated from the plant under consideration no less by its stout spines, than by the presence on its twigs and pods of the viscid secretion so characteristic of *viscosa*.

Since Pursh's name *rosea* is excluded by the previous use of it by Marshall and du Monceau for *R. hispida*, and no other has been published, I propose the name *Boyntonii*, complimentary to Mr. F. E. Boynton of Biltmore, N. C., an observer having a most extensive acquaintance with the southern Appalachian flora.

The proposed species is characterized as follows:

Robinia Boyntonii, sp. nov.

Robinia hispida var *rosea* Pursh, Fl. Amer. Sept. 2:488.

Robinia rosea D. C. Prod. 2:262.

Robinia hispida (in part) Gray, Man. Fifth ed. 131.

Mature twigs 3-4mm thick, terete, a bright varnished brown, glabrous; stipules minute, awl-shaped, caducous; shoot of the season at first minutely pubescent, at length glabrous or nearly so. Leaves 10-16cm long, leaflets 9-13, mostly placed alternately, short-stalked, oblong or oblong-ovate, 2-4cm long, 1-2cm wide, tipped with a slender mucro. Petiole and leaflets minutely pubescent when young, soon glabrous. Racemes axillary, erect or nodding, 7-9cm long, one-half to two-thirds the length of the leaves, rather loosely 8-12 flowered. Flowers on slender, erect or spreading pedicels 4-5mm long, rose-purple, pink, or purple and pink on the outer portion, white or much paler towards their base, when expanded

[5] In Desv. Journ. Bot. 4: 204.

[6] London (Trees and Shrubs Brit. 236) stated that it is a hybrid which originated in 1730.

barely 2cm long; blade of wing abruptly contracted into the slender claw; keel rather broad, (each portion) spatulate in outline. Calyx short, 6mm in length, as broad as long, the very short, broad lobes, 2-3mm long, abruptly acute, smooth, or minutely pubescent when young. Pod slender, many seeded, smooth, even when young.

A shrub with virgate branches, 1.5m to 2.5m in height, or exceptionally larger and assuming an arborescent form. Mountains of Virginia (?) and western North Carolina to Georgia, usually at high elevations. It is one of the handsomest of the Appalachian species of the genus, equalling in brilliance of color and abundance of flowers R. viscosa. Growing specimens of this plant have been extensively distributed by the Kawana Nurseries of Kawana, N. C.

Specimens examined:

Kelsey: Mitchell county, N. C.
J. A. Tatham: Cherokee county, N. C.
Ashe: Randolph county, N. C.
Ashe: Greenville county, S. C.

The plant is local, but fairly abundant where it occurs, and it should be frequent in cultivation. *Robinia hispida* L. with which it has been confused has the following characters:

Robinia hispida L., Mant. 1: 101.
Robinia rosea Duham., Arb. 1. *t.* 18.
Robinia rosea Marsh., Arb. 134.
Robinia montana Bartr., Trav. 335.
Pseudacacia hispida Moench, Meth. 145.
Aeschynomene hispida Roxb. (?)

Mature twigs rather stout, 4-5mm thick, terete, dark brown, bristly-hispid, papillate, or nearly smooth. Shoot of the season from densely bristly-hispid with stiff purple hairs to nearly smooth; stipules, minute early deciduous. Leaves rather large, 12-20cm long, petiole usually hispid; leaflets 7-11, rarely 13, mostly opposite, short-stalked, ovate or orbicular, 2-3cm wide, 2-4cm long,

tipped with a short, stout mucro, cordate or subcordate at base, more or less pubescent when young, soon smooth. Racemes axillary, nodding or drooping, 3-5 flowered, 4-5 cm long, one-fifth to one fourth the length of the leaves, peduncles usually hispid. Flowers purple-blue in the bud, becoming on expansion deep purple or red-purple, but lighter-colored at the base, when open 2.5cm or more long; blade of wing projecting beyond point of union with claw, so as form a narrow but deep sinus between them; each division of keel oblong, abruptly contracted into the claw. Calyx 8-10mm long, the 4-7mm long acuminate lobes much longer than the short broad generally hispid tube. Pod short, stout, few-seeded, glandular-hispid.

A low straggling shrub, 1-3 feet in height. It occurs from Virginia to Georgia and Alabama? in and near the mountains. In the mountains it is for the most part confined to the crests and dryer southern flanks of ridges, and is not uncommon. Its altitudinal distribution is from 300m to 1500m. It seems to pass gradually into the low-country form which is nearly destitute of bristles and more or less pubescent.

Robinia Boyntonii is separated from *R. hispida* L. by its greater size, smooth pod, oblong leaflets, many-flowered racemes, short calyx-lobes and smoothness.

From *R. viscosa* Vent. it is separated by having only about one-half the number of leaflets, a smooth pod and the absence of viscid secretion.

In many characters it is nearly allied to *R. Pseudacacia* L: The leaflets are about the same number, twigs and pods are smooth; but the flowers are rose-colored and smaller than in *R. Pseudacacia* and no stipular spines are developed.

Since the above was put in type I find that *Robinia* Boyntonii has been distributed by the Biltmore Herbarium, but without a name, as No. 3268: Near Highlands, Macon county, N. C.

ON THE ORIGIN OF THE VERTEBRATE SENSE ORGANS.

BY H. V. WILSON.

The belief that the chief sense organs of vertebrates have been evolved from a longitudinal series of simple and superficially situated organs rests on morphological evidence, which if not conclusive is yet very considerable.

Beard[1] in 1885 described in selachian embryos a series of rudimentary sense patches (ectodermal thickenings), on eabove each gill cleft. These he termed the branchial sense organs. Similar organs have been found by Beard and several observers (Froriep, Kupffer etc.) in the embryos of other Ichthyopsida, birds, and mammals. It may be confidently asserted that a phylogenetic significance attaches to these formations, and that the ancestors of existing vertebrates had a series of sense organs (two series, one more dorsal than the other: Kupffer) situated in the anterior (branchial) region of the body.

The sense organs of the lateral line, and of the mucus canals of the head, found in adult fishes, tailed amphibia, and in anuran larvae, are known to arise by the proliferation of the above mentioned embryonic organs, which thus became extended far beyond the seat of their original appearance.

The position and mode of origin of the embryonic nasal and auditory invaginations led Beard to regard these organs as homologous with his series of branchial sense organs. And this conclusion has been in general accepted by later investigators.

It might some years ago have seemed impossible to in-

[1] Branchial Sense Organs of Ichthyopsida. Quart. Journ. Micr. Sci. 1885.

clude the eye in this lateral series of homodynamous organs. But while the eyes (optic vesicles) ordinarily originate as diverticula from the fore-brain, it is now known that in many forms they make their appearance as invaginations of the surface ectoderm, long before the neural folds have closed. In this condition the optic vesicle is a circular depression, substantially like the auditory or nasal pit. Later these depressions are carried inwards with the invaginating neural plate, and then appear as outgrowths of the brain. The early appearance of the optic vesicles has long been known in mammals, but until within recent years it has been regarded as a peculiar and precocious feature of this group. Through the observations of Whitman[2], Eyclesheimer[3], and Locy[4], we have learned that the optic vesicles originate in this manner in several amphibia, in selachians, and the chick. These observations at least lend us a basis for the comparison of the eyes with the other segmentally arranged sense organs, and meantime (Locy lc. p. 556) "we are in the attitude of awaiting further facts."

The scattered integumentary sense organs (taste buds, touch corpuscles) have not been shown to be derived from anlages, serially homologous with the anterior segmentally arranged series.

The derivation of the chief vertebrate sense organs from a longitudinal series of superficial neuro-epithelium patches, might at first thought be construed into a sound argument for the annelid-theory of vertebrate ancestry. But when it is borne in mind that the vertebrate series is, in the embryo, confined to the anterior (branchial) region, *whence the organs spread back over the trunk and forwards over the head by proliferation*, it will be recog-

[2] Journal of Morphology, 1889, p. 593.

[3] Journ. Morphology, 1893, Vol. VIII, No. 1, p. 189.

[4] Contributions to the Structure and development of the Vertebrate Head. Journ. Morphology, 1895.

nized that this series of organs differs at any rate in the matter of distribution, from the segmentally arranged organs extending along the side of the body of certain annelids (Capitellidae, Eisig[5]; leeches, Whitman[6].)

The small number and local distribution of the segmental sense organs of the vertebrate embryo, as compared with the condition after the lateral line has become well developed, suggests inevitably the question: If so much of the metameric character of these organs in the adult (or larva) is clearly secondary, how deeply seated is the metameric arrangement of the primitive (few, embryonic) branchial sense organs? Is it possible that this series of organs has arisen from a single pair (one on each side of the body), as some (Brooks[7]) believe the gill clefts to be traceable to a single pair?

There exist certain observations which it is possible to interpret as supporting this idea. In 1891 I described[8] for a teleost (Serranus embryos) a sensory anlage on the side of the head. The reference to these observations in Minot's Human Embryology (1892) is succinct, and indicates the state of our knowledge on this point at the time: "This thickening (the anlage on each side of the head) forms a long shallow furrow, which subsequently divides into three parts, of which the first becomes a sense organ over the gill cleft, the second, the auditory invagination, and the third, the anlage of the sense-organs of the lateral line. This peculiar development confirms the notion that all these organs belong in one series, but the appearance of a continuous thickening as the anlage of them all, has as yet been observed only in this fish, and may not indicate a corresponding ancestral condition. Unfortu-

[5] Die Segmental-organe der Capitelliden. Mitt. a. d. Zool. Sta. zu Neapel, 1879.

[6] "Some New Facts about the Hirudinea." Journ. Morphology, 1889.

[7] The Genus Salpa. Baltimore, 1893.

[8] Embryology of the Sea Bass. Bull. U. S. Fish Comm. Vol. IX.

nately Wilson was unable to make out anything as to the connection of the sensory plate with the ganglia. The sense organ above the gill cleft, although differentiated, is a larval structure only, and disappears in the adult" (quoted from Locy lc. p. 548).

Locy writing on elasmobranch development (1895, lc.) goes on to show the advance of our knowledge in this matter—"A quite similar condition is now known to obtain in some elasmobranch forms. Mitrophanow in 1890 published a preliminary report of his observations on the lateral line of Acanthias and other elasmobranchs. In 1893 he published a full report of the same, illustrated by many figures. He describes a continuous thickening of the epidermis along the sides of the head, embracing the territory of the roots of the seventh to tenth nerves. From this thickening there is separated the material for the auditory saucer, the branchial sense-organs, and the beginning of the lateral line. My observations on this region in Squalus agree with those of Mitrophanow." Locy's observations are briefly described further on in his paper (p. 517), the author mentioning that "a consideration of the so-called branchial sense-organs and their ganglia is reserved to be published later."

The discovery that the common anlage was not a peculiar feature of a teleost species, but existed in widely different Ichthyopsida (Mitrophanow[9] describes the anlage not only for selachians, but for teleosts, cyclostomes, and amphibia as well), indicated that the point was one worth following up.

The Serranus egg is a small, pelagic egg. In it the common anlage is more sharply differentiated from the general ectoderm, than in the selachian and cyclostome forms studied by Mitrophanow and Locy. In Serranus the anlage is a furrow, in the latter forms it is a thicken-

[9] Etude embryogénique sur les Sélaciens. Arch. de Zool. exp. et gen 1893.

ing. In the teleost forms studied by Mitrophanow (species not stated) the anlage develops in same way as in Serranus—as a furrow.

The salmon egg is very different from that of Serranus. It is large, and with relatively firm yolk. At my suggestion Mr. J. E. Mattocks undertook the problem of ascertaining in the first place, whether the common anlage existed in the salmon embryo, and if so, what was its character. The result of Mr. Mattocks's work (published in Anat. Anzeiger XIII Bd. Nr. 24), was to show that the common anlage does exist in the salmon; that it is not a furrow, as in Serranus, but a thickened stripe of ectoderm as in selachians; that it divides into three parts, the middle becoming the auditory sac, the posterior the rudiment of the lateral line, and the anterior remaining as a very noticeable thickening situated above the anterior gill clefts. It thus turns out, as might have been expected, that the peculiarly distinct, furrow-like character of the analge in Serranus, is not universal in teleosts. The difference in the character of the anlage between Serranus and Salmo is perhaps associated with the difference in the character of the two eggs. One is small, light, the embryo cosisting of comparatively few cells, the other large, heavy, the embryo relatively massive and of many cells. Without dwelling on this point (which like other similar questions can be cleared up only by an extensive comparative study of closely related forms, aided, where the method is practicable, by intelligently "put" experiments—in this connection see Davenport's very suggestive "Catalogue of the processes concerned in Ontogeny." Bull. Mus. Comp. Zool. Vol. XXVII. No. 6), it is safe to say that comparative embryology lends some support to the generalization that in embryos of the former type invagination or evagination is apt to occur, while in embryos of the latter type the invagination or evagination is frequently represented by solid in-

growths or ontgrowths (i. e. thickenings)—compare for instance the formation of the mesoblast of Amphioxus with that of other vertebrates, the invaginate gastrula of Leucifer with the corresponding stage of such a form as the lobster.

If we suppose (as a basis for further work, rather than for any other purpose) that the common lateral anlage in the ichthyopsidan embryo indicates the presence in the chordate ancestors of a single elongate sense-organ on each side of the hean, then what was the character of this organ? Was it a sac (groove), or merely a superficial sensory area? It is worth while often, to put the question, even if the answer is not forthcoming. Certainly the answer is not now at hand. Though merely putting the qnestion calls to mind the cephalic slits of nemerteans, and Hubrecht's ingenious, if not very popular theory of chordate ancestry.

NOTES ON NORTH CAROLINA MINERALS.*

BY J. H. PRATT.

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INTRODUCTORY NOTE.

The contents of this paper are notes on the North Carolina minerals that have been collected during the past few years. Some of these have already been published

*By permission of the Director of the N. C. Geological Survey.

during the past year, and reference is made to this under the head of these minerals.

These notes are intended primarily for a Bulletin on the Mineral Resources of North Carolina, but the more important of these are published as occasion offers.

WELLSITE, A NEW MINERAL.*

Occurence.—This mineral occurs at the Buck Creek (Cullakanee) corundum mine in Clay Co., North Carolina, and was collected by Professor S. L. Penfield and the author during the summer of 1892 while engaged in work on the North Carolina Geological Survey.

The corundum vein in which the mineral is found is composed chiefly of albite feldspar and hornblende, and penetrates a peridotite rock, dunite, near its contact with the gneiss. The peridotite outcrop is one of the largest in the State and has been thoroughly prospected for corundum. At only one of the veins opened was the new mineral found, although a careful search was made for it at all the openings, especially those affording feldspar. No mining has been done at the locality since 1891, but if work is resumed and the veins uncovered, more of the material will undoubtedly be found.

The mineral is found in isolated crystals mostly attached to the feldspar but also to hornblende and corundum, and is intimately associated with chabazite, (see p. 70), which occurs in small transparent rhombohedrons.

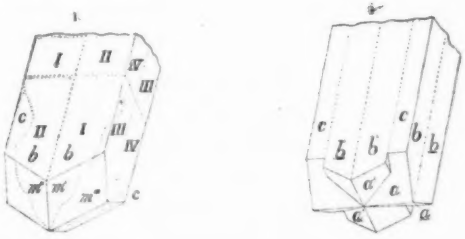
The largest crystals that were observed were not over 1^{mm} in diameter and 2^{mm} in length.

Crystalline form.—The crystals belong to the monoclinic system and they are twinned similarly to those of harmotome and phillipsite. The common habit is shown in fig. 1, which represents a combination of twinning about c, 001 and c, 011. The crystals are practically square prisms, terminated by pyramidal faces, thus imi-

*Am. J. Sci. Vol. III, p. 443, 1897.

tating closely a simple combination of a prism of one order and a pyramid of the other in the tetragonal system. The apparent prismatic faces are formed for the most part by the pinacoid faces, *b*, but the crystals interpenetrate each other somewhat irregularly so that portions of the base *c*, 001, coincide with *b*, fig. 1. The lines of twinning on the pinacoid faces between *b* and *b* twinned are generally regular, while those between *b* and *c* and also those which cross the prism faces *m*, 110 (the apparent pyramid) are generally quite irregular. The *b* faces do not show the striations parallel to the edges *b* and *m*, which, meeting along the twining lines, often reveal the complex nature of such crystals, nor were any reëntrant angles observed parallel to the edges of the apparent prism as are common on phillipsite and harmotome.

Fig. 2 represents another habit of the crystals where *m*, 110 is wanting and *a*, 100 is in combination with *b*, 010. The method of twinning is similar to that already described, but the crystals being terminated by *a*, 100 instead of *m*, 110 show prominent reëntrant angles at their ends. These crystals are very similar to those of harmotome from Bowling near Dumbarton on the Clyde, described by Lacroix.*



The only forms that were observed were *a*, 100; *b*, 010; *c*, 001 and *m*, 110, with *c*, 011 only as twinning plane.

The faces of the crystals are somewhat rounded and

*Bull. de la Soc. Min. de France, No. 4, p. 94, 1885.

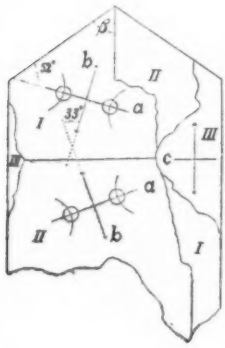
vicinal so that the reflections were not very perfect. The angle of the apparent prism $b \wedge b$ twinned is approximately 90°. Also the angle $m \wedge m$ over the twinning plane 011 could be measured only approximately, varying from 0°49′ to 1°25′. The approximate angles are given below, and from those marked with an asterisk the following axial ratio was calculated:

$$a:b:c = .768 : 1 : 1.245; \ \beta = 53°27' = 001 \wedge 100$$

	Measured	Calculated.
$b \wedge \underline{b}$, 010∧010	*90° (over twinning plane)	
$a \wedge \underline{a}$, 100∧100	*73°6′ (over twinning plane)	
$b \wedge m$, 010∧110	*58°19′	
$c \wedge a$, 001∧100	$53°27' = \beta$	
$c \wedge m$, 001∧110	60°, 59°45′, 59°57′	59°33′

Physical properties.—The crystals are brittle and show no apparent cleavage. The luster is vitreous. Many of the crystals are colorless and transparent while others are white. The hardness is between 4 and 4·5. The specific gravity taken on a number of separate crystals, by means of the heavy solution, varied between 2·278 and 2·366. This variation was probably due to the difference in the ratio of the barium to the calcium in the different crystals.

3.



A section parallel to the pinacoid faces b, 010, the apparent prism, revealed in polarized light the structure shown in fig. 3. The parts I and I extinguish simultaneously, as also II and II; while portions III, which are parallel to the basal plane, show parallel extinction. The section showed something of a zonal structure, so that the extinction could only be measured approxi-

mately. Using the Bertrand ocular, this was found to be 33° from one pinacoid on to the other over the twinning plane. The axis a makes an angle of 52° with the vertical axis c' in the obtuse angle β.

The double refraction is positive and weak. The acute bisectrix c is at right angles to the pinacoid 010, and the divergence of the optical axes is large. 2E probably varies from 120° to 130°, but this could not be measured directly.

Chemical analysis.—The mineral was purified for analysis by means of the heavy solution and that which was used varied in specific gravity from 2·278 to 2·360.

The analyses were made by Mr. H. W. Foote,** who describes the methods used as follows:

"Water was determined by loss on ignition, and silica and alumina by the ordinary methods after fusion with sodium carbonate. The filtrate from the alumina precipitation was evaporated with aqua regia to remove the large excess of ammonium salts and a small amount of ammonium chloride was again added. Calcium, barium and strontium were then precipitated together, with a considerable excess of ammonia and ammonium carbonate, and magnesia was determined in the filtrate. The mixed carbonates were dissolved in hydrochloric acid evaporated to dryness and taken up in about 300cc of water. The method used for separating barium was that recommended by Fresenius.* To the hot solution, a few drops of acetic acid were added and 10cc of a 10 per cent solution of ammonium chromate containing a small amount of dichromate. After standing until the solution became cold, the clear liquid was decanted and the precipitate of barium chromate was washed with a weak chromate solution and with water. The precipitate was

*Zs. Anal. Chem., xxix, 426.

**Of the Chemical Laboratory of the Sheffield Scientific School, New Haven, Conn.

dissolved in 2cc of pure dilute nitric acid, which was then partly neutralized with ammonia. Ammonium acetate was added and 10cc of chromate solution as before, and after standing, the precipitate was filtered on a Gooch crucible and weighed as $BaCrO_4$.

"The filtrate from the barium precipitation was concentrated somewhat, and calcium and the small quantity of strontium precipitated as before. They were ignited and weighed as oxide. Strontium was then separated by treatment with amyl alcohol and determined as sulphate.

"The alkalies were determined by a Smith fusion in the ordinary way."

The results of the analyses are as follows:

	I.	II.	Average.	Ratio.	
SiO_2	43·62	44·11	43·86	·731	= 3·00
Al_2O_3	25·04	24·89	24·96	·244	= 1.00
BaO	5·00	5·15	5.07	·033	
SrO	1·12	1.18	1.15	·011	
CaO	5·76	5·84	5·80	·104	·228 = ·93
MgO	0·61	0·62	0.62	·015	
K_2O	3·40		3·40	·036	
Na_2O	1·80		1·80	·029	
H_2O	13·32	13.39	13.35	·742	= 3.04
			100·01		

The ratio of $SiO_2 : Al_2O_3 : RO : H_2O$ is very close to $3 : 1 : 1 : 3$, which gives the formula $R''Al_2Si_3O_{10} \cdot 3H_2O$. The ratio of $BaO : CaO : K_2O + Na_2O$ in the above analyses is nearly $1 : 3 : 2$ and the theoretical composition calculated for this ratio is given below together with the analysis after substituting for Na_2O its equivalent of K_2O and for MgO and SrO their equivalents respectively of CaO and BaO and then recalculating to 100 per cent.

		Theory for $R''Al_2Si_3O_{10} \cdot 3H_2O$ where R is $\frac{1}{4}$Ba, $\frac{3}{4}$Ca, $\frac{3}{4}$K.
SiO_2	43·12	42·87
Al_2O_3	24·54	24·27
BaO	6·65	6·62
CaO	6·59	7·27
K_2O	5·98	6·10
H_2O	13·12	12·87
	100.00	100·00

Experiments were made to determine at what temperatures the water was driven off, and the results are given in the following table, the mineral being heated in each case until the weight became constant. The last trace of water could only be driven off by heating the mineral over the blast lamp.

	Loss.	
At 100° C	nothing.	
125	1·93	4·33
175	1·48	
200	0·92	
260	2·45	3·69
295	1·24	
Red heat	4·96	5·29
Over blast lamp	0·33	
Total	13·31	

As is seen from the above, about one-third of the water, or one molecule, is given off between 100° and 200°, another third approximately between 200° and 300°, while the remainder is expelled only at an intense heat. This would indicate that the water exists in three different conditions in the molecule. If only that which is expelled below 200° be regarded as water of crystallization, the composition would be $H_1R''Al_2Si_3O_{12}+H_2O$.

That the new mineral would be closely related to the

phillipsite group of the zeolites, was expected from the first on account of its crystalline form, and this relation is very satisfactorily brought out by a comparison of the crystallographic properties and chemical composition.

They all have very nearly the same axial ratios:

	a	b	c	
Wellsite	·768	1	1·245	$\beta=53°\ 27'$
Phillipsite	·70949	1	1·2563	$\beta=55\ 37$
Harmotome	·70315	1	1·2310	$\beta=55\ 10$
Stiblite	·76227	1	1·19401	$\beta=50\ 49\frac{3}{4}$

In their habit and method of twinning, they are also very similar, all the crystals being uniformly penetration twins. This is especially noticeable between the new mineral and phillipsite and harmotome which are common as double twins with c, 001 and e, 011 as twinning planes.

The place of the mineral in the phillipsite group is clearly shown by a comparison of their chemical compositions. Arranged in order of their proportions of silica and water to the bases, we have the following interesting series, in which R represents the bivalent elements:

Wellsite ..... $RAl_2Si_3O_{10}.3H_2O$
Phillipsite ..... $RAl_2Si_4O_{12}.4\frac{1}{2}H_2O$
Harmotome ..... $RAl_2Si_5O_{14}.5H_2O$
Stilbite ..... $RAl_2Si_6O_{16}.6H_2O$

The ratio of $RO:Al_2O_3$ is constant, 1:1, in the series, while the proportions of silica and water have a constant ratio, 1:1, between themselves, except in the case of phillipsite. As there is, however, considerable variation in the analyses of phillipsite, it is not improbable that the ratio of $SiO_2:H_2O$, given as $4:4\frac{1}{2}$, should be in some cases at least, 4:4. The minerals then form a gradual series, increasing in the proportions of SiO_2 and H_2O from wellsite to stilbite.

Fresenius* has shown that this group of minerals may be regarded as a series in which the ratio of $RO:Al_2O_3$ is

*Zs. Kr., III, 42, 1878.

constant, 1:1, while the silica and water vary between certain limits. He has assumed as these two limits:

$$RAl_2Si_6O_{16}+6H_2O \text{ and}$$
$$R_2Al_4Si_4O_{16}+6H_2O$$

The first would be a hydrated calcium albite and the last a hydrated anorthite. From a comparison of the wellsite-stilbite series, it seems more probable that the anorthite end would be $RAl_2Si_2O_8+2H_2O$, or doubling this for better comparison with the formula of Fresenius, $R_2Al_4Si_4O_{16}+4H_2O$.

It is not unreasonable to expect that the first or anorthite member of this series may be found in nature and the completed series would then be:

Anorthite limit . . . $RAl_2Si_2O_8+2H_2O$ (not yet identified)
Wellsite . . . . . $RAl_2Si_3O_{10}+3H_2O$
Phillipsite . . . . . $RAl_2Si_4O_{12}+4\frac{1}{2}H_2O$ (perhaps $4H_2O$)
Harmotome . . . . . $RAl_2Si_5O_{14}+5H_2O$
Stilbite . . . . . $RAl_2Si_6O_{16}+6H_2O$

It is also interesting to note that the formula of the new mineral wellsite is the same as that assigned to edingtonite, but the latter is essentially a barium mineral and being tetragonal shows no crystallographic relations to wellsite.

Pyrognostics.—When heated before the blowpipe, the mineral exfoliates slightly and fuses at 2·5–3 to a white bead, coloring the flame slightly yellow. In the closed tube, water is given off at a low temperature. It is very readily decomposed by hot hydrochloric acid with the separation of silica, but without gelatinization. When the water in the mineral is driven off below 265° C., it is nearly all regained on exposing the mineral to the air. If the water, however, is driven off at a red heat, none is regained by the mineral.

Name.—The name *Wellsite* is given to this mineral in honor of Professor H. L. Wells of the Sheffield Scientific School, Yale University.

CHABAZITE.

Occurrence.—As described on page62, this mineral is intimately associated with the wellsite, at the Buck Creek (Cullakanee) corundum mine in Clay Co., occurring as a mass of small crystals coating the feldspar, hornblende and corundum. Thus far this mineral has been found only at the large open cut on the eastside of Buck Creek, just northwest of the shaft.

The crystals are transparent to white and very small, no crystal being found that measured over one millimeter in diameter.

The only form observed on any of these crystals was the unit rhombohedron, 1011, which occurs as simple crystals and also as penetration-twins, with c^3, as the twinning axis.

Chemical analysis.—In obtaining material for analysis, the crystals of the chabazite and wellsite, freed as far as practicable from the feldspar and hornblende were crushed and sifted to a uniform grain. By means of the heavy solution, the chabazite was separated from the wellsite and also from any feldspar or hornblende that may have been attached to them. All of the chabazite floated, when the specific gravity of the solution was 2.-278, while the wellsite and heavier minerals sank to the bottom of the separatory funnel. These were drawn off and the solution diluted to a specific gravity of 2.244, but only a small per cent. of the mineral sank. This being drawn off, the solution was further diluted to a specific gravity of 2.203, when nearly half of the remaining mineral sank. This was removed and saved for analysis, (II, below) and the solution again diluted. When the specific gravity had been lowered to 2.147, all, but a small amount of the mineral came down, and this was saved for analysis. (I) A preliminary experiment had been made with the crystals of the chabazite and these were found to vary considerably in specific gravity.

The mineral was analyzed by Dr. Chas. Baskerville* with the following results:

	I Sp. Gr. 2·147-2·303	Ratio			II Sp. Gr. 2·203-2·244	Ratio		
SiO_2	45·08	·751		= 3·79	46·15	·769		=3·79
Al_2O_3	19·68	·193		= 1.00	20·74	·203		=1.00
FeO	2·00	·028			2.00	·028		
CaO	7·22	·129	·163	= ·84	6·92	·124	·158	= ·77
BaO	·18	·001			·24	·001		
MgO	·23	.005			·22	·005		
K_2O	4·34	·064	·100	= ·50	4·10	·043	·097	= ·47
Na_2O	3·35	·054			3·35	·054		
H_2O	18.00	1·000		= 5·02	16·30	.905		=4·46
	100·08				100·02			

The ratio of $Al_2O_3 : SiO_2 : H_2O$ is near to 1 : 4 : 5 and $Al_2O_3 : (R''.K_2.Na_2)O$ is close to 4 : 5.

Usually in the composition of the chabazites the ratio of $Al_2O_3 : (Ca . K_2 . Na_2)O$ is near to 1 : 1. In the present analysis, no attempt was made to separate any strontium present from the calcium. As a small amount of this element would cause considerable variation in the per cent of CaO, this would readily account for the excess of this oxide in the analysis.

The composition of the chabazite has always been somewhat uncertain as there is often a wide varation in the analyses of specimens from the same locality. The hypothesis advanced by Streng,† that the chabazite is an isomorphous mixture of

$$\left.\begin{matrix} m(CaNa_2)Al_2Si_2O_8+4H_2O \\ n(CaNa_2)Al_2Si_6O_{16}+8H_2O. \end{matrix}\right\}$$

explains satisfactorily the variations observed in this

*Of the Chemical Laboratory, N. C. Geological Survey.

†Ber. Oberhess. Ges. 16, 74, 1877 and Dana Mineralogy, sixth edition, 1892, p. 591.

mineral. This is analogous to the composition of the albite-anorthite feldspars.

The approximate ratios deduced from the above analyses, of $SiO_2 : Al_2O_3 : (Ca.Na_2)O : H_2O = 4 : 1 : 1 : 5$, would give for the formula of this chabazite $m : n$, but with a low amount of water.

The variation in and the high specific gravity of the mineral is without doubt due to the varying proportions of barium and strontium in the molecule.

The occurence of the chabazite at Buck Creek is interesting as being the only known locality of this mineral in North Carolina.

ANORTHITE.*

The occurrence of this feldspar at Buck Creek, Clay Co., N. C., has been described by J. V. Lewis.** The mineral forms with olivine a mass of forellenstin (troctolite) rock, outcropping over an area of about two acres, at the extreme eastern border of the peridotite outcrop. The particles of feldspar vary in size from that of a pea to some nodules that were an inch and a half long by three-quarters of an inch broad and are separated from the olivine by a zone of fibrous silicates, composed partly of enstatite.

The two cleavages are well developed in all the specimens of the mineral and in many of these the striations on the basal cleavage are very distinct.

The feldspar has suffered some kaolinization but the interior of the larger nodules is apparently free from all decomposition. By means of the heavy solution a product was obtained for analysis that varied in specific gravity from 2·6995 to 2·7440.

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*Am. J. Sci. Vol. V, 1898, p. 128.

**N. C. Geological Survey, Bulletin 11, p. 24.

The results of the analysis made by Dr. Chas. Baskerville* are as follows:

		Ratio.		
SiO_2	44·05	·734		2·23
Al_2O_3	30·87	·302		·92
FeO	·84	·011		
CaO	17·30	·308	·328	1·00
MgO	·36	·09		
Na_2O	3·65	·057		
K_2O	·83	·009		
Moisture	·35			
Loss on ignition	1·60			
	99·85			

The ratio of $SiO_2 : Al_2O_3 : CaO$, is near to 2 : 1 : 1, which identifies the feldspar as an anorthite.

With the exception of a small amount of this mineral found at Shooting Creek, Clay Co., under similiar conditions, this is the only occurrence of anorthite in this State.

ANTHOPHYLLITE.

In 1890 Prof. S. L. Penfield† described this mineral which was reported as having come from the Jenks coumdum mine near Franklin, Macon Co., N. C.

During the summer of 1892, while engaged with the North Carolina Geological Survey, Prof. Penfield and the author visited an outcrop of dunite rock near Bakersville, Mitchell Co. On breaking open one of the loose boulders of decomposed dunite rock, *anthophyllite* was exposed, which Prof. Penfield at once recognized as identical with the specimen he had described.

As there has been no mention of the correct locality of

* Of the Chemical Laboratory N. C. Geological Survey.

†Am. J. Sci. XL, 1890, p. 394.

the anthophyllite and as this name is often applied to an enstatite occurring at the corumdum mine, it has been thought that a description of the occurrence of these two minerals would be of interest.

At the Woody place two and a half miles south of Bakersville on the Marion road, there is a large outcrop of dunite rock extending from near the road to the top of the hill, a lenticular mass about 600 by 300 feet. The hillside, where it occurs, is quite barren and thickly scattered with loose fragments and boulders of the altered dunite. The outcrop has been carefully examined but the anthophyllite has only been found in the boulders. The mineral occurs in prismatic crystals imbedded in penninite. Nearly all the crystals are seamed and cracked while those near the outer part of the boulders are somewhat decomposed and stained a dirty brown. The purest crystals are transparent, and vary from pale clove brown to a flesh color.

The crystals measure from 2^{mm} to 6^{mm} in the widest diameter and in length, some were found that were over three centimeters.

A great many crystals were examined but no terminated ones were observed. The unit prism, 110, occurring alone, or in combination with the brachy pinacoid, 010, were the only forms observed.

Although the boulders containing the anthophyllite are composed almost always of this mineral and penninite, there are other minerals, resulting from the alternation of the chrysolite, which occur at this locality. These are magnetite in perfect octahedrons 1^{mm} in diameter, green actinolite, chalcedony, druzy quartz, talc, serpentine and genthite. Chromite occurs in grains in the chrysolite.

An analysis of the anthophyllite by Dr. Baskerville is given below, together with the results obtained by Prof. Penfield.*

	I (Baskerville).	II (Penfield).
SiO_2	56.40	57.98
Al_2O_3	1.15	.63
FeO	11.40	10.39
MnO	- - -	.31
MgO	28.68	28.69
CaO	.50	.20
H_2O	1.63	1.67
Loss at 100°	- - -	.12
	99.76	99.99

The two analyses are very similar, and confirm Prof. Penfield's conclusion that the specimen described by him was from the Bakersville locality.

One specimen of a true anthophyllite was found at Corundum Hill by Prof. Penfield; but this was more fibrous and not of such good quality as that from the Bakersville locality.

ENSTATITE.

The enstatite from Corundum Hill that is commonly called anthophyllite, occurs as a rock composed of a mass of interlocking bladed grayish crystals of the mineral. The rock is very tough and tenacious and forms a perfectly continuous mass with the dunite. The outcrop of the dunite at Corundum Hill is very similar to that near Bakersville. The hill of nearly ten acres in extent ha the dunite exposed over nearly its entire surface, and the enstatite is found at the lower south end of the outcrop in the zone of alteration products developed near the contact of the dunite with the hornblende gneiss.

*Am. J. Sci. XL, 1890, p. 396.

The analysis of this mineral by Dr. Baskerville* is as follows:

		Ratio	
SiO_2	51.64	.861	
Al_2O_3	.12	.001	
FeO	9.28	.129	
MnO	.56	.008	.943
MgO	31.93	.798	
CaO	.45	.008	
H_2O	5.45	.303	
	99.43		

It is evident from the amount of H_2O found, that the material analyzed was not pure, but was probably a mixture of the enstatite with serpentine and talc.

As is shown by the calculations below, the ratio in the above analysis would be satisfied by a mixture of 44.5 per cent. enstatite, 35 per cent. serpentine and 20.5 per cent. talc. The analysis is also given below after substituting for MnO and CaO their equivalents of MgO, deducting Al_2O_3 and recalculating to 100 per cent.

	44.5 per cent. Enstatite.	Ratio.	35 per cent. Serpentine.	Ratio.	20 per cent. Talc.	Ratio.	Total.	Recalculated Analysis.
SiO_2	24.42	.407	14.87	.246	13.02	.217	52.31	52.19
FeO	7.58	.105	1.84	.025	---		9.42	9.39
MgO	12.50	.312	13.83	.346	6.51	.163	32.84	32.91
H_2O	---		4.46	.246	.97	.054	5.43	5.51
	44.50		35.00		20.50		100.00	100.00

ENSTATITE (BRONZITE.)

The occurence of this mineral in any considerable amount in North Carolina was first mentioned by Dr. G. H. Williams** who described specimens of a bronzite-diopside rock, to which he gave the name websterite.

*N. C. Geol. Survey, Bull. 11, p. 27.

**American Geologist VI, pp. 43-4, 1890.

†J. V. Lewis N. C. Geol. Survey, Bull. 11, p. 27.

These specimens were collected near Webster, Jackson Co., by Mr. Geo. P. Merrill of the U. S. National Museum.

On the road from Webster, following up the Tuckaseegee river valley and about one half mile from the town, a mass of dunite† is exposed for over 1500 feet on a hillside facing the river. In the midst of this outcrop, the websterite occupies a width of nearly 300 feet. This outcrop of dunite is very similar to that near Bakersville and at Coumdum Hill, described above.

This rock as described by Williams,* is composed entirely of bronzite and an emerald-green diopside. The ground mass of this rock is composed of the brilliant green grains of the diopside through which rounded crystals of the pale brown bronzite are disseminated. The relative amount of the bronzite is variable as it shows a tendency to concentrate in nests or bands.

Lewis** speaks of this rock as a compact granular rock closely resembling the dunite with which it is associated.

Near the north end of the dunite outcrop, at the side of the road, boulders were observed, which when broken open were found to be composed almost entirely of bronzite. Besides the boulders a mass of the same rock was observed apparently *in situ*.

The bronzite composing this rock is of a resinous brown color, and of a bronze like luster, even on the unaltered surfaces. On the cleavage surface the luster is decidely pearly. No distinct crystals were observed, the specimens being a mass of interlocking crystals making a very tough rock similiar to the enstatite described above. In most of the specimens, the crystals were so interlocked that no crystal outline of these could be distinguished. In a few of the specimens the crystals were much larger

*American Geologist VI, pp. 43—4, 1890.

**N. C. Geol. Survey Bull. 11. p. 27.

in their development and their outline could readily be detected. Some of the crystals measured 2^{cm} in the direction of the *b*, axis.

Associated with the bronzite is the emerald-green diopside mentioned by Williams, which is sparinglg scattered through the rock in very small, clear, green grains.

While the websterite is composed of a base of diopside grains with the rather large rounded crystals of the bronzite penetrating through it, the bronzite rock is essentially interlocking prismatic crystals of the bronzite with a few grains of the diopside disseminated through it. This rock, also, does not show any of the granular character of the websterite; but on the contrary it is very compact and tough.

The material for analysis was hand picked and that selected showed no impurities or decomposition when examined with the magnifying glass.

The results of the analysis by Dr. Baskerville are given below:

		Ratio		
SiO_2	53·62	·894		=1
Al_2O_3	·97	·009	·012	
Cr_2O_3	·50	·003		
FeO	9·06	·125	·994	=1·11
CaO	1·75	·031		
MgO	33·53	·838		
H_2O	·19			
	99·62			

In the above analysis the ratio of the bivalent oxides to silicia is close to 1 : 1, and of ferrous oxide to magnesia and lime is very near to 1 : 7; this would give the formula $(MgFe)SiO_3$ with Mg : Fe = 7 : 1. Assuming that the Al_2O_3 and Cr_2O_3 belong to spinel and deducting RO sufficient to combine with them, the analysis, after substituting for CaO its equivalent of MgO and recalculating to

100 per cent, is given below together with the theoretical composition calculated for this formula.

	Found	Theory for $(MgFe)SiO_3$: Mg : Fe=7 : 1
SiO_2	55·35	57·69
FeO	9·14	8·65
MgO.....	35·51	33·66
	100·00	100·00

The name bronzite is very appropriate to this Webster enstatite, for the luster is of a decided bronze-like character throughout the entire mass and is undoubtedly not of a secondary origin, but is the natural luster of this mineral. A similiar bronzite, showing the same decided bronze-like luster has been found at the Buck Creek, (Cullakanee,) corundum mine in Clay county.

EMERALD BERYL.

Although the beryl is a very common accessory mineral, in granite veins, especially those of a pegmatitic character, it is not common to find the deep emerald green variety. The earliest report of the emerald in North Carolina is 1880, by W. E. Hidden* who describes the occurrence in Sharpes Township, Alexander Co. where it is found associated with the emerald green hiddenite.

The occurence of the emerald in Mitchell Co. has been known since 1886, though but little work has been done to develope the locality and to estimate its economic value. The mineral is found on the divide between Brush and Crabtree Creeks about four miles south of Spruce Pine, post office.

The vein carrying the beryl is of a pegmatitic character consisting chiefly of quartz and an albite feldspar, with

*Elisha Mitchel Scientific Society. 1880.

tourmaline, garnet and the beryl as accessory minerals. The country rock is a gneiss and biotite schist.

The emerald beryl has the characteristic green color of the gem and some of the crystals are transparent. They all have the hexagonal prism well developed, but none were observed that showed any terminations. The crystals vary in size from less than a millimeter up to eight millimeters in diameter. They are found imbedded in the quartz, feldspar and biotite schist, but are for the most part near the contact of the vein with the schist. The most transparent and deepest green crystals observed were either entirely surrounded by the schist or close to the contact. Those in the quartz were usually more transparent than those found imbedded in the feldspar. The color of the crystals varies with their location in the vein, those nearest the schist being of the emerald variety, while those farther away are pale green or yellow.

The yellow or cream colored beryls are very abundant though the vein. The crystals vary considerably in size, from those hardly 2^{mm} in diameter to one that measured 17^{cm}.

The locality as yet has not been developed sufficiently to demonstrate whether it will warrent its being worked for gems. Both Col. Rorison of Bakersville, and Capt. Isaac English of Spruce Pine report that crystals have been found from which good gems were cut.

GRASS GREEN CYANITE.*

The mineral to be described occurs on the farm of Tiel Young, near North Toe River, Yancey Co., North Carolina, a few miles from Spruce Pine, Mitcheli Co.

Some exceptionally large crystals of a grass-green color were obtained by the author during the summer of

*Am. J. Sci. Vol. V, 1898, p. 126.

1896 from Mr. M. Alexander, a jeweler in Asheville. After some difficulty the occurrence was located, during the summer of 1897, and the locality has been thoroughly worked by Geo. L. English & Co. of New York, with the result that many good crystals of the cyanite have been obtained.

The mineral occurs in a decomposed mica schist from which the single crystals are easily separated. The crystals are often intergrown and masses of these were obtained as large as one's two fists. All of the crystals found were of a rich grass-green color and many were quite transparent. A few of the crystals showed a deep blue center with the grass-green margins. The crystals vary in size from $1\times\cdot7^{cm}$ to $3\cdot2\times6^{cm}$; a few coarser ones were observed that were considerably larger. The finest crystal that has been found at this locality measured $5\cdot8\times2\cdot2\times1\cdot8^{cm}$ and was perfectly transparent at one end for about 2^{cm}. The three pinacoids were the only faces observed on this crystal and these were evenly and well developed. This crystal is now in the Brush Collection at New Haven, Conn. The faces are generally smooth, giving fair reflections of the signal on the reflecting goniometer.

The forms observed on these crystals are as follows.

c, 001	*a*, 100	*M*, $\bar{1}10$	
b, 010	*m*, 110	Q, 120	*l*, 520

The face 520 is apparently a new one for cyanite. The three pinacoids were the only faces observed on the majority of the crystals, some of which were doubly terminated. After a very careful examination of the terminatio s, they were decided to be real basal planes and not cleavage surfaces. On one of the crystals, all of the faces observed were developed.

The following table shows the identification of the forms by calculated and measured angles. In obtaining the calculated angles the elements given in Dana's Min-

eralogy (1892), deduced from Rath's measurements* on Greiner crystals, have been used.

$a':b:c' = 0{\cdot}89938:1:0{\cdot}70896$; $\alpha = 90°5\frac{1}{2}'$; $\beta = 101°2\frac{1}{4}'$; $\gamma = 105°44\frac{1}{2}'$

		Calculated.	Measured.
$a \wedge m$,	$100 \wedge 110$	34° 17′	34° 17′ ; 34° 20′;
$a \wedge M$,	$100 \wedge 1\bar{1}0$	48 18	48 43 ; 48 41; 48° 45′
$a \wedge Q$,	$100 \wedge 120$	48 43	48 50
$a \wedge l$,	$100 \wedge 520$	17 9	17 13
$a \wedge b$,	$100 \wedge 010$	73 56	73 40 ; 73 38; 73 42
$b \wedge M$,	$010 \wedge 1\bar{1}0$	57 46	57 41

The specific gravity is 3·64 and was determined upon several different samples. Pleochroisim is very strong.

Iron and chromium were very carefully tested for, but no trace of either was observed in the analysis, which showed only the presence of alumina and silica.

Crystallized cyanite is usually in long bladed crystals without terminations, the best crystals having been found at St. Gothard in Switzerland and on Mt. Greiner in Tyrol. These crystals of a blue and blueish white color, are often transparent but are seldom over a few millimeters wide.

This new occurrence of the cyanite is not only of interest on account of the deep green color of the mineral but also on account of the exceptional size and development of the crystals.

Pale green cyanite has been obtained from a number of localities and it has also been found in the vicinity of the green cyanite locality on the farm of Isaac English of Spruce Pine, Mitchell Co., imbedded in an undecomposed mica schist. Another occurrence that is worthy of note is that of Graves Mt., Georgia. At this locality thin small plates of the pale green cyanite are associated with well crystallized rutile.

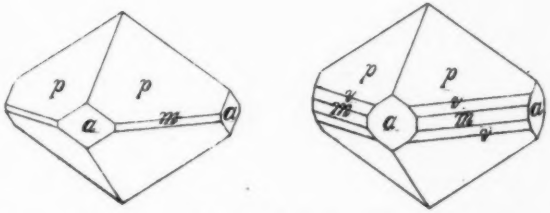
*Zs. Kr., v, 17, 1880.

ZIRCON.*

Some specimens of zircon crystals were obtained of Messrs. Geo L. English & Co., from New Stirling, Iredell o., CNorth Carolina, and on account of their size and development it has been thought a description of them would be of interest.

The crystals are all very similar in their habit, in which the unit pyramid is strongly developed while the prisms faces are short, figs. 4 and 5. Fig. 4 represents the majority of the crystals, where the prism of the first order is only slightly developed, at times being hardly perceptible. Those represented by fig. 5 are similar in their habit to some zircon crystals described by the au-

4. 5.



thor from the townships of Dungannon and Faraday, Ontario.†

The following forms were observed on these crystals:

a, 100; *m*, 110; *p*, 111; *v*, 221; *x*, 311.

The face *x*, 311 was only observed on a very few of the crystals and was but slightly developed. The crystals are all well developed with smooth faces, making them well adapted for measurement on the reflecting goniometer. Although the author had no reflecting goniometer at hand, the faces were readily identified by means of the contact goniometer.

The crystals vary in size from 1^{cm} to $2{\cdot}5^{cm}$ in diameter and are of a reddish-brown color.

*Am. J. Sci. Vol. V, 1898, p. 127.

†Am. Jour. Sci., vol., xlviii, p. 215, 1894.

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